

Research

EXECUTIVE SUMMARIES : BY RONALD ASKIN



Daniel Reaume (left) of General Motors and Marina Epelman of the University of Michigan worked with colleagues to formulate an algorithm that helps schedule upgrade events during a line's downtime.

This month we highlight two articles that employ dynamic programming to make better decisions. The first article develops a decision support tool for helping production managers schedule upgrade events during line downtime. The second article addresses how frequently partial information should be shared among groups in a concurrent integrated product development environment. These articles will appear in the December issue of IIE Transactions (Volume 45, No. 12).

How can we use line shutdowns to improve performance?

Sustaining the performance of modern production lines involves completing many tasks in a timely fashion: preventive maintenance, calibrations, installations and upgrades. But these tasks often require increasingly rare downtime for their completion. Moreover, even when downtime is available, a task often requires that the line be shut down in a particular configuration.

For example, suppose a station is scheduled to be upgraded to improve its quality or reliability. For safety or accessibility reasons, the station might need to be empty of jobs. And to validate the upgrade, a supply of a variety of job types might be

required immediately upstream, together with sufficient buffer space downstream to accept these jobs after they are processed.

Production managers thus face the challenging problem of how to coordinate shutdowns of various line segments to enable as many task completions as possible. The future benefits of task completions must be balanced against the immediate costs of lost production and overtime incurred by shutting down the line before or after the scheduled end of a shift. Without an appropriate decision support tool, managers usually resort to simple rules of thumb in making shutdown decisions, leading to significantly suboptimal shutdown policies. Moreover, unexpected equipment breakdowns might invalidate a carefully thought-out shutdown plan.

The problem of optimally shutting down a production line is investigated in "A Dynamic Programming Approach to Achieving an Optimal End-State Along a Serial Production Line." In this paper, professor Shih-Fen Cheng from the Singapore Management University, Blake Nicholson from Facebook, professor Marina Epelman from the University of Michigan, Daniel Reaume from General Motors, and professor Robert

Smith from the University of Michigan develop an efficient dynamic programming (DP) formulation of the problem. They also propose a DP-based, event-triggered re-optimization algorithm that effectively handles unexpected breakdowns.

By using data from an actual production line, the authors demonstrate the potential utility of their approach. In particular, simulation experiments demonstrate that shutdown policies computed by their algorithm significantly improve upon a typical rule-of-thumb approach used in practice.

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To consider or not to consider: That is the question

Integrated product development (IPD) utilizes overlapping task activity in order to improve development performance (e.g., time and cost). Overlapping entails the concurrent execution of nominally sequential activities through the exchange of partial information.

For example, consider the development of a new laptop table consisting of a six-week upstream marketing stage and a 12-week downstream design stage. The marketing team can share preliminary information after two weeks (i.e., after completing some customer interviews). Marketing also might share updated customer information at the end of each week thereafter. For the design team, there is a setup time to consider the information (time to review and discuss the marketing data). Upon assessing the quality of the information, the design team may perform rework. Given these setup times, the key question is whether the design team should consider the information at the end of each week.

This question is addressed via a stochastic dynamic programming (DP) model in “Optimal Information Exchange Policies in Integrated Product Development” by professors Ali Yassine and Bacle Maddah of the Engineering Management Program at the American University of Beirut. We make the assumption that the quality of information provided by an upstream activity is random, i.e., mimics a coin toss. The probability of obtaining useful information increases as the development process evolves. That is, the quality of marketing information improves as development progresses. The DP model allows developing the optimal information processing strategy for all information scenarios.



Ali Yassine (left) and Bacle Maddah discuss the mathematical foundations of the information exchange model within an integrated product development process.

For a two-stage IPD, the study finds that the optimal policy is of “threshold type,” which depends on the last period where rework was performed. For the laptop table development example, it turned out that in week six, information should be considered by the design team if the last rework was performed in week three or earlier. The study also considered three-stage IPD by, for example, adding a testing stage to the laptop table development example. The study found that integration leads the midstream activity (e.g., design stage) to consider more information, and early on, compared to the two-stage process.

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